Appendix 2-2

UV Irradiation

UV IRRIDATION

1.1 General Description

UV disinfection is a physical disinfection process, as opposed to a chemical disinfection process, that relies on the transference of electromagnetic energy from a source to the cellular material of an organism. The germicidal effects of UV light involve photochemical damage to RNA and DNA within the cells of an organism. This UV energy causes permanent, irreparable, inactivation of the microorganism by fusing together and forming dimmers within portions of the DNA strands prohibiting replication. The microorganism becomes unable to maintain metabolism or reproduce itself and subsequently perishes. The germicidal effects of UV light are greatest at wavelengths from 240 to 260 nanometers (nm). Although certain chemical compounds can be altered by UV radiation, it is generally thought that the compounds are broken down into more innocuous forms (WERF, 1995).

1.2 Operating Principle

For disinfection applications, UV energy can be artificially generated by striking an electric arc through mercury vapour. The discharge of energy generated by excitation of the mercury results in the emission of UV light. UV light can be produced from either low-pressure or medium-pressure (high intensity) mercury lamps, with the difference in terminology indicating the relative pressure of the mercury vapour within the lamp. While the low-pressure lamps emit approximately 90 percent of their light at 254 nm, the medium-pressure lamps emit higher-intensity radiation across a broader spectrum of radiation and therefore require fewer lamps but more power.

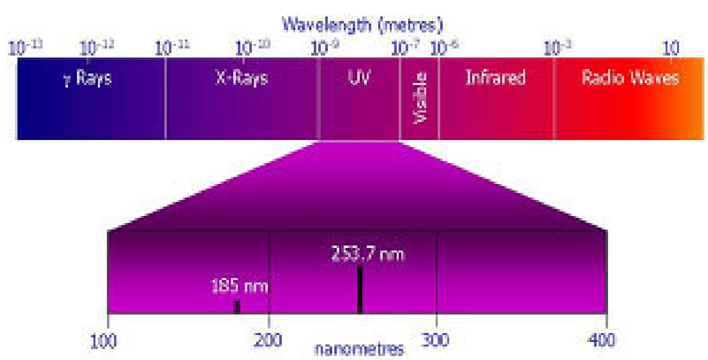

Figure 1.2 Identification of UV Radiation in Electromagnetic Spectrum

The inactivation of microorganisms is based on the UV dose (mJ/cm^2), which is a product of the light intensity (mW/cm^2) and the exposure time (seconds). The UV dose term is analogous to the dose term used for chlorine disinfection (i.e. "CRT" value). The design of UV disinfection system is based on the UV dose required to achieve the required degree of disinfection. After determining the UV dose required for adequate inactivation of the target microorganism, optimal UV system configuration could be designed based on the specific performance of UV disinfection system.

Another important parameter for UV disinfection process is the UV transmittance (or UV absorbance/demand) of wastewater, which measures the ability of UV light to penetrate wastewater and is hence a critical factor in designing the UV disinfection system. The transmittance value, measured in a spectrophotometer, is a function of all the factors which absorb or reflect UV light. Therefore, lower the UVT of wastewater, less UV radiation would be effective for disinfection and more UV lamps would be required. Examples of UV absorbing compounds include humic materials, oil and grease, TSS, iron compound, manganese compound and proteins.

Operation of UV disinfection system is dose-paced, which means the UV dose can be varied by changing either the UV intensity or the exposure time, and thus achieve a more cost effective disinfection process.

1.3 UV Disinfection System Components and Configurations

The principal components of a UV disinfection system consist of (1) the UV lamps, (2) the quartz sleeves in which the UV lamps are placed, (3) the UV module for holding/supporting the UV lamps and quartz sleeves, (4) the ballasts used to regulate power supply to the UV lamps, and (5) the power supply panels for supplying power to the UV disinfection system.

UV disinfection system can be categorized according to the type of lamp used, such as low-pressure and medium pressure (high intensity) UV lamp as mentioned above. In addition to the type of lamp used, UV disinfection system can also be classified according to whether the flow occurs in open or close channels. Mechanical cleaning systems are used to avoid fouling of the quartz sleeves and to maintain the effectiveness of disinfection process. The open-channel systems are superior to closed chamber system which often proved problematic and maintenance-intensive for wastewater applications (USEPA, 1986). The lamps are typically inserted in modules that can be easily removed from the channel for periodic cleaning. The modular technology has simplified replacement of system parts including lamps, and has allowed installation of banks of UV lamps in series, which has enabled the application of UV disinfection technology to larger wastewater treatment plants.

1.4 Operating Experience

Local UV Disinfection Installation for CEPT

At present, there are two CEPT treatment works with UV disinfection systems. They are the Cyber Port STW and Sham Tseng STW. The operational information of the UV disinfection systems installed in these two STWs is summarized as follow:

Table 1.4.1 Local UV Disinfection Systems

Details	**Cyber Port STW**	**Sham Tseng STW**	**Unit**
CEPT Effluent Characteristics			
Peak Flow	30,500	50,500	(m^3/day)
Coagulant Type	Alum	Alum	-
BOD, mg/L	125	180	95 Percentile (mg/L)
TSS	125	100	95 Percentile (mg/L)
UVT@254nm (unfiltered)	35%	35%	Minimum (%)
Effluent Bacterial Standard			
Effluent E.Coli	20,000 300,000	4,000 60,000	Monthly GM (counts/100mL) 95 Percentile (counts/100mL)
UV Disinfection System			
Type	Closed-channel, Medium-Pressure, High-Intensity	Open-channel, Low-Pressure, High Intensity	-
Manufacturer	Berson	Wedeco Inc.	-
No. of UV lamps	96	468	(Nos.)
Commissioning Year	2002	2004	-

It is reported that both STWs can achieve the required discharge bacterial standard. In addition, upgrading of the Siu Ho Wan STW (SHWSTW) with UV disinfection system for disinfection of the CEPT effluent is also under construction and the reliability trial and commissioning will be started in the end of year 2006.

Overseas UV Disinfection Installation for CEPT

Currently, Canada has approximately seven (7) UV systems for disinfection of CEPT effluent. The plants were commissioned in 1998 or 1999. The design information of the installations is shown in **Table 1.1**.

Table 1.1 Primary or CEPT plants with UV Disinfection Systems

Location	**Flow (MLD)**	**UVT (%)**	**Startup Year**	**Disinfection Standard** (count E.coli per 100ml)
La Piniere PQ	300	40	1998	2500
Beloeil PQ	55	40	1998	400
Beaupre PQ	30	35	1998	3200
La Malbaie PQ	30	40	1998	400
Rosemere PQ	26	38	1999	500
Boischatel PQ	18	40	1998	650
Gaspe PQ	17	40	1999	300

Source: Sand Island Wastewater Treatment Plant Disinfection Study, January 2000, City and County of Honolulu.

In Canada, three installations including La Piniere, Bioschatel and Beaupre are reported to use alum currently as the primary coagulant. The effluent TSS standards are set to be 25, 30 and 30 mg/L for the three plants based on maximum monthly averages, respectively. The effluent TSS levels are low, probably due to the dilute influent characteristics in Quebec, Canada. The effluent BOD levels are found to range from 15 to 72 mg/L. It is not known regarding the exact coagulant dosage and surface overflow rates of these plants. All these three installations in Canada use medium-pressure high-intensity UV systems for effluent disinfection. Their design UV dose levels range from 18 to 24 mWs/cm^2. The effluent bacteria standards are expressed in terms of maximum monthly geometric means using fecal coliforms as indicator organisms. Note that the indicator microorganism used in Hong Kong is E.Coli, which is a subgroup of fecal coliforms (i.e.

all E.Coli is fecal coliforms but some species of fecal coliforms are not E.Coli). Therefore, for the same numeric limits, the standards using fecal coliforms in other CEPT installations are more stringent. Based on the operating experience at Beaupre, there does not seem to have any difficulty to use dose levels of 20 to 25 mWs/cm^2 to achieve the required bacterial standard.

UV disinfection has been adopted in the following advanced primary or CEPT plants. Currently, the UV systems of the plants are being constructed or commissioned.

- Sand Island, U.S. (advanced primary) : 450 MLD
- Halifax NS, Canada (CEPT) : 200 MLD
- Darthmouth NS, Canada (CEPT) : 120 MLD
- Herring Cove NS, Canada (CEPT) : 40 MLD

1.5 Local UV Disinfection Pilot Test at Stonecutters Island STW for CEPT Effluent

A UV pilot plant study of design capacity of 200m^3/h and consisted of a total of 8 medium-pressure high intensity lamps took place from August to October 1999 at Stonecutters Island STW. Treated effluent from the prototype CEPT plant adjacent to the pilot unit was used as the source of influent to the UV pilot unit. Effluent and influent samples were collected for E.Coli and other water quality analyses.

The UV pilot test showed that the required E.Coli standards were achieved at practical dose level. An UV dose levels less than 30 mWs/cm^2 was found to be sufficient to achieve the E.Coli standards of 20,000 counts/100ml at all times over a wide range of influent conditions. Higher dose levels appeared to be necessary at higher TSS levels, although the trend was not apparent for some TSS ranges because of the significant data scattering. Moreover, the fouling rate was found to be acceptable. Based on this study, the fouling rate for the ferric chloride effluent would be approximately four hours. In the event that alum was used as the coagulant, the fouling rate would be approximately twelve hours based on this study. The expected fouling rate and required frequency of cleaning should be acceptable using the UV systems with automatic wipers.

1.6 Overseas UV Disinfection Installation for Secondary Effluent

While UV radiation is relatively new for disinfecting CEPT effluent, its application for disinfecting secondary and tertiary effluent is now widely accepted in U.S and other countries. Some installations are listed **in Table 1.2** .

Table 1.2 Secondary / Tertiary treatment Plants with UV Disinfection Systems

Plant/Country	Peak Capacity (MLD)	Level of Treatment	Startup Year
Ringsend WTP, Ireland	959	Secondary	2003
Cronulla WTP, Australia	432	Tertiary	2001
Megere WTP, New Zealand	300	Tertiary	2003
Nelson Complex WTP, U.S.	236	Secondary	2000
Li Giao WTP, China	220	Secondary	2004
City of Ann Arbor WTP, U.S	218	Secondary	2000
Edinburgh Seafield WTP, Edinburgh	77	Tertiary	2001
City of Jefferson WTP, U.S.	27	Secondary	2002
Mil Cove WTP, Canada	19	Secondary	1997